The AUTOMATIC ELECTRIC Technical Journal

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IMRE MOLNAR began his telephone work in Europe on major installation projects from 1921 to 1925. After graduating in Communication Engineering (U. of Berlin, '30), he worked for the Automatic Electric Group in installing, circuit design, and transmission engineering, and served as resident engineer abroad. In 1937 Automatic Electric assigned him to circuit designing and in 1943 to the Laboratories as a Project Engineer. He received the Ph.D. degree in Electrical Engineering from Northwestern University in 1950. Dr. Molnar is a member of The American Institute of Electrical Engineers and Sigma Xi and a senior member of The Institute of Radio Engineers.

EDWARD J. GLENNER graduated from Northwestern University with the degree of B.S. in E.E. in 1948. He started at Automatic Electric Company in the Training School, then was assigned to Systems Engineering and the Testing Bureau. In 1950 he taught two classes in circuit operation in the Automatic Electric Training School. Since then he has been working on toll system development as Development Engineer in the Product Design Section of the Laboratories. Mr. Glenner is a member of Eta Kappa Nu, the electrical engineering honorary fraternity.

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THE TYPE 6 INFORMATION BOARD

By OWEN G. JARBOE

General Traffic Manager, General Telephone Company of California

SYNOPSIS: ***Function of Type 6 Information Board—structure and operation — summary of operation — advantages of new design.***

DURING the early summer of 1949 General Telephone Company of California, with headquarters at Santa Monica, California, began consideration of the type of equipment that would be used to replace its outmoded and overloaded shop-built Information switchboard at the Santa Monica centralized information bureau. The existing 16-position switchboard provided information service for 79,440 primary stations in the Santa Monica, West Los Angeles and Malibu exchanges. Local information for telephones in these exchanges was given from rotary information files. In addition, information concerning the extended-service calling areas contiguous to these exchanges was furnished from printed information directories. Customers obtained information service for the remainder of the Los Angeles extended-service area by dialing the toll operator, who connected them to the Los Angeles centralized information switchboard operated by Bell in downtown Los Angeles. The General Company had agreed to take over the handling of this Los Angeles extended-area toll information, which would require 8 additional switchboard positions. Thus, it was estimated that a total of 24 Information positions would be required by July 1952.

With the assumption of the Los Angeles extended-area toll information load, requiring reference to printed directories, it was decided to abandon the use of the rotary information files for local information and to give all information from the existing printed records used by Bell in this area. The Los Angeles extended-area has

Figure 1. Close-up view of a position on the Type 6 Information Board.

more than 1,800,000 listings contained in five volumes which, in addition to the sprawling city of Los Angeles, list other cities within a 40 cent calling radius, including those served by General. The information directories are reprinted monthly by the Pacific Telephone and Telegraph Company; daily accumulative supplements to these directories are issued five days per week.

Functions of Type 6 Information Board

The objectives to be provided in the new Information Switchboard were:

1. Rapid speed of answer (Automatic call distribution).
2. Simplicity of operation.
3. A means of indicating an overload to the central office management.
4. An arrangement of information records that would reduce the period of search to a minimum and at the same time call for the least possible physical exertion on the part of the operator.
5. Conservation of floor space and concentration of supervision.
6. Positive identification of the calling local customer by exchange.
7. Trunk concentration.

With this bill of requirements before them, General's Traffic Engineers happened coincidentally upon the description of the Automatic Special Service Desk by H. W. Balzer in the April 1949 issue of the Automatic Electric Technical Journal. This desk, they felt, with some changes in the cabinet, would do everything they wanted it to do. Modifications desired consisted of lowering the pitch of the directory shelf, providing a book rack for holding miscellaneous directories and records, and separating positions by means of clear plastic "partitions" in order to reduce interference from adjacent operators. (This last has had the further and unexpected result of greatly reducing interference from room noise.)

One problem, which had to do with requirement No. 4, had already been solved. This concerned the need for providing a means of rapidly searching through five large printed Information directories containing 1,862,000 listings without the need of lifting them from and replacing them on a shelf. This was accomplished simply by an ordinary multiple directory holder of the type used on directory shelves at pay stations. The manufacturer of this device agreed to modify it to General's specifications, which required that the holders be lengthened to cover most of the wide shelf of the Automatic Electric Type 6 Information Board. This arrangement, which is illustrated in

Figure 1, has proved to be the answer to this problem, and has since been adopted by some of the other telephone companies operating in the Southern California area.

The changes in the original design of the cabinet having been agreed upon, and the arrangement for mounting the directories having been perfected, an order was placed for 24 positions of the Automatic Electric Type 6 Information Board. The new board (see Figure 2) was cut into service February 17, 1950. A general description of its operation follows.

Structure and Operation

The Automatic Electric Type 6 Information Board automatically distributes incoming information calls to idle operators by means of trunk-finding equipment located in the terminal room. The problem of terminating a large number of key-ended trunks on the switchboard, and of "grading" these trunks so as to provide an even load between operators, is therefore eliminated. Calls waiting are "stored" by the equipment and fed into the switchboard in the sequence of their origination, thus eliminating a problem which is inherent in older types of switchboards. Furthermore, each information trunk has access to the entire team of operators, so the answering time is "leveled off" on all calls, and each call receives a near average answering time.

The method of operation of the manual features, all contained in the cabinet illustrated in Figure 3, is quite simple. The operator, to activate her position, plugs into the headset jack and operates one of two keys at the left to the "talk" position. Normally all traffic is handled over one key (or "link"); however, if the operating practice permits having two calls under way at one time (which it does not with the General Company) this may be accomplished by operating the key on the first link on which a customer is waiting to a "NORMAL" position and then operating the key associated with the second link to the "TALK" position. Under this condition the first call is held while the operator answers the second one. This arrangement is used in extending a call to a supervisor. It may also be used to extend a call to a subscriber's line (as, for example, in an emergency) but this provision was not required in this installation.

When a call is connected to a link equipment at a position, the busy signal lights, and it remains lighted until the link is released. At the same time a "zip" tone is received by the operator on toll information calls to indicate that a toll operator is on the line; a "zip-zip" tone is received when the call is from a customer requesting local information. The different classes of calls are indicated to the operator by the group identity lamps, but these tones also assist in identification.

The group identity lamps are located at the top of the cabinet, beneath the designation strip, and

Figure 2. Twenty-four-position Type 6 Information Board at General Telephone Company's headquarters in Santa Monica, California.

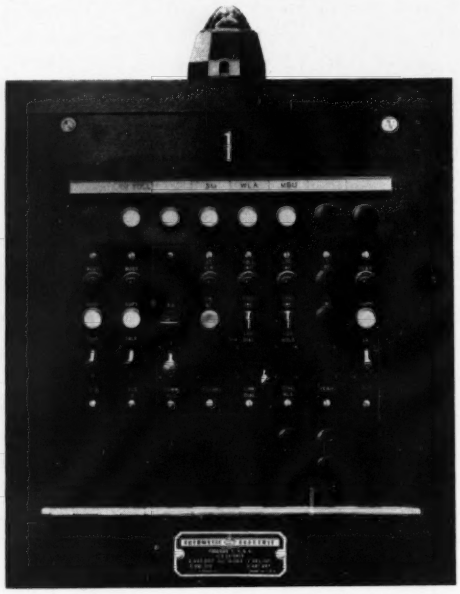

Figure 3. Keyshelf equipment for Type 6 Information Board.

are associated with the various trunk groups. One of these signals lights automatically when a call is received by an operator, thus permitting her definitely to identify its source by office and/or class. In the Santa Monica installation, information calls only are handled; this accounts for the fact that only exchange-name abbreviations are shown on the designation strip—except for toll information from the Santa Monica toll board, which is also designated "SM TOLL."

The class or classes of calls to be handled by a position are regulated by locking-type turn keys located in the fifth and sixth escutcheons from the left in the turret—see Figure 3. (In this illustration neither of the two keys provided is operated.) Should it be desired to receive only local information calls the key designated "LOC. INF." is operated so that the white line on the key is horizontal. If toll information only were to be handled on this position, the key designated "TOLL INF." would be operated. If intercepting calls were to be handled at the switchboard, the seventh escutcheon would be equipped with a lamp and key, and properly designated for intercept service. In Figure 3, the seventh escutcheon is not equipped, but is designated for future use in the handling of inter-toll information "I.T. INF." Answer pilot lamps are associated with each class-of-service key so the operator can tell when a call of that class is waiting. Class-of-service pilot lamps light only for those classes which are "turned on" by operation of the locking keys at a position.

The key blank in the fifth key escutcheon, designated "LINK DIAL", may be equipped for the purpose of completing calls received over an information or intercepting trunk to stations in the automatic central office. To do this the link key is left operated in the "TALK" position and the "LINK DIAL" key is operated. After the called number is dialed by the operator she closes the "LINK DIAL" key. When conversation is finished the supervisory signal on the link will light. The operator may monitor the connection by operating the "LINK DIAL" key, and can release the dialed line without releasing the calling party by operating the key in the sixth escutcheon to the position marked "DIAL RLS." During a conversation on one link, calls may be received on the second link.

The key position marked "LOC. DIAL" (local dial) may be equipped to enable the operator to originate a call through the local automatic equipment. By this means she may call repair service, the toll switchboard, another information bureau or a local subscriber. If it is necessary for the operator to leave the connection, she may hold it by operating the key in the sixth escutcheon (shown unequipped) to the position designated "LOC. HOLD."; an associated lamp (shown unequipped) is located directly below the sixth key escutcheon to remind the operator that she is holding a call.

The seventh escutcheon has provision for the installation of a verifying key for use in offices where the operating practice calls for verifying busy conditions at this board. Where the verifying feature is equipped, two supervisory lamps should be provided in drilled spaces at the right of and below the face equipment. One supervisory lamp would indicate whether the verifying circuit (which would be multipled in several positions) was available. The other would light when the line being verified was seized. The operation of the verifying key would connect the verifying circuit, which utilizes a test distributor, to the position dial.

The eighth escutcheon contains equipment for the handling of supervisor calls. To transfer a call to the supervisor the key of the link on which the subscriber is being held is left in the "TALK" position. The supervisory key is then operated momentarily to the "SR" position. This will cause a supervisor's division signal to flash, indicating the division in which the call originated (the division signals are shown in Figure 2 on pipe stands mounted on top of the key cabinets); an audible signal sounds during operation of the "SR" key; at the same time, a "bee-hive" supervisor signal will light on the position originating the call. Also, at this position, the white signal marked "SUPY" will light, and in all positions within the supervisor's section the red "busy" lamp will light to guard against the use of the circuit by other operators.

The operator may cut out of the connection by restoring the link key from the "TALK" position to normal position. When the supervisor plugs into the supervisor's headset jack, all signals in the circuit go dark except for the "busy" signal. Should the operator wish to talk to the supervisor before connecting the calling party, she may do so by closing the link key on which the customer is being held and operating the second link key to the "TALK" position at the same time the supervisor's key is operated. She may then connect the calling party to the supervisor by restoring the key on the second link and operating the key on the first link as previously described.

When the calling party hangs up, the link circuit is released. When the supervisor has finished with the subscriber and retires from the line, the "SUPY" lamp lights and the operator releases the supervisor circuit.

Should the supervisor have to check a listing in the directory, thus making it necessary to leave the switchboard, she can hold the customer on the supervisor's circuit by operating a "HOLD" key that has been provided in the lock rail adjacent to the supervisor's headset jack. She may then go to her own supervisor's stand, where, by plugging in her headset, she can pick up the supervisor's circuit on which the customer is being held.

The supervisor's stand, illustrated in Figure 4, was designed by General Telephone Company. The handset shown, which is used to originate calls to the outside, is to be replaced by a two-way key and separately mounted dial, permitting the supervisor to originate exchange calls through her headset. Directories provided at the supervisor's stand include, in addition to the subscribers' alphabetical directories, certain "last reference" directories, such as the classified, which are not provided the operators.

At Santa Monica, toll service is given by The Pacific Telephone and Telegraph Company in a separate building nearby. Accordingly, dial assistance calls which would normally be handled on the toll board are instead trunked by means of a separate subscriber-dialed code to a low-type cord board which also handles intercepting service, across the room from the Type 6 Information Board (see Figure 5). At some periods during the night, information calls are handled at this board, which is activated by the operation of a locking key. The information signals then appear on position 1. In the keyshelf of this position, in addition to its regular equipment, is installed a duplicate of the Type 6 Information Board position equipment. This provision for the handling of all types of traffic from one board at night has been made in the interest of economy and service since at some periods of the night only one operator is on duty.

The subscribers' local information directory for Santa Monica, which is integrated in the "Western" section of the Los Angeles extended-area directory, is published once a year. Information calls are, therefore, understandably higher at certain

Figure 4. Supervisor's stand for Type 6 Information Board.

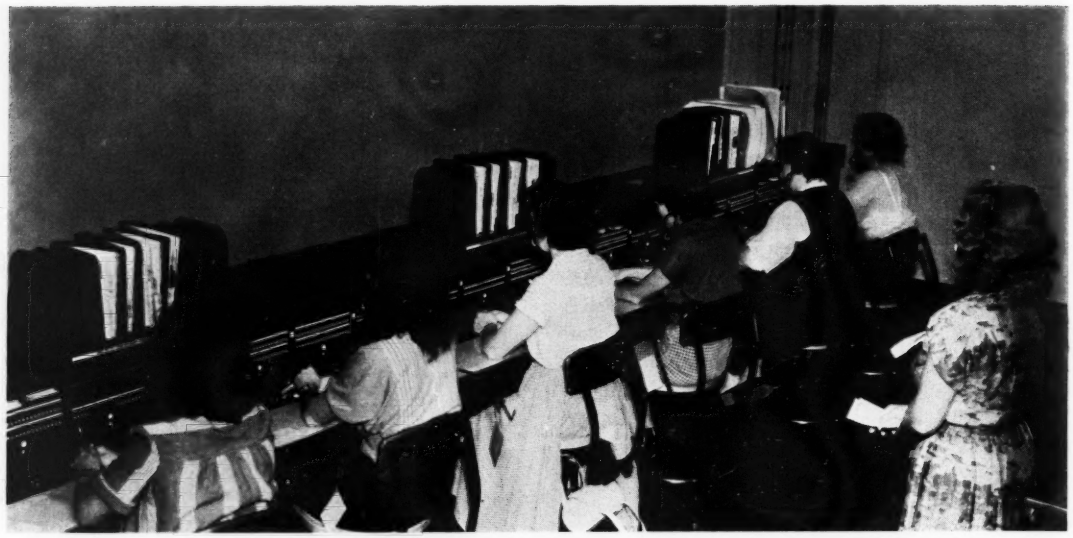

Figure 5. Low-type cord board which handles dial assistance calls and intercepting service.

periods of the year than at exchanges where publication is on a more frequent basis. Calls handled at the Type 6 Information Board have run as high as 16,300 per day, which at times slightly exceeds the capacity (15,333) of the 24 positions. 1,533 calls are handled during the busy hour—sixty-four per operator.

Two additional sections (eight positions) are soon to be installed, making a total of 32 positions, which are expected to be sufficient until December 1956. Thirty-two regular operators and four supervising operators will then handle 20,448 information calls per business day at Santa Monica. As previously mentioned, the speed of handling is expected to increase as the turnover is reduced and the experience factor improves.

Summary of Operation

For the purpose of correlating the various operations of the Type 6 Information Board in the mind of the reader, let us follow the actions of an operator who is taking over the operation of a position.

After plugging in her headset jack she will first condition her position to receive the type of calls she is assigned to handle, i.e., local information, toll information, or inter-toll information. She will do this by operating the locking turn-button keys in the fifth, sixth and seventh escutcheons. *Note:* A predetermined selection of the type of calls to be handled at any one or all positions may be arranged by wiring within the position; at Santa Monica, where only information calls are handled, this feature is used merely to assign the handling of incoming toll information to certain positions. In other situations—for example, where both information and intercepting calls are handled at the same board—this feature would be of considerable value, since in this case operators could specialize on one or the other types of traffic, thus increasing their proficiency. Another benefit would be the reduction of the number of records it would be necessary to provide and maintain.

An added feature of the equipment is the provision for arranging the selection of type of traffic by preference, so that, while only one type of traffic will normally land on a position, lulls in this traffic will be filled by other types of calls, if any are waiting. For example, an operator may be assigned to handle only information calls but to team with the intercepting operators if they become overloaded. This very flexible arrangement will act to reduce operating costs as well as to improve service where distinct teams of operators are assigned to different classes of traffic.

The operator's next action will be to operate one of the link keys in the first or second escutcheon to

the "TALK" position. Her position is now ready to receive calls.

Let us now assume that an information call lands on the operator's position. The operator will receive a zip-zip tone in her headset, indicating that a customer is on the line. Simultaneously she will note that a white signal has appeared in the top row of lights. This prepares her to deal with this customer with a knowledge of his location so that she may take into account any particular conditions pertaining to his office. The value of this feature becomes immediately obvious if the call is an intercepting call rather than one for information; in this case the operator, while answering and as an overlapping operation, would reach for the proper intercepting binder, since it would be unnecessary for her to question the customer as to the location of the called station.

The operator answers with an appropriate phrase depending upon the type of call, and having given the desired information to the customer, operates the common-release key which frees the link for receipt of another call. The subscriber may also release himself from the Type 6 Information Board by depressing his switchhook; however, use of the common-release key by the operator eliminates the time lag of the subscriber's hang-up; this method of release is accordingly recommended to increase the call capacity of the board and to improve the service. Care must be taken, however, to see that the customer is not released before he can confirm the information received or ask for supplemental information.

Of special interest to the office management is the lamp signal display panel which is mounted on the wall in full sight of the Chief Operator and other central office management personnel. This panel of lamps, which may be seen in Figure 2 on the back wall and which is pictured in detail in Figure 6, indicates the number of calls waiting to be answered; in other words, the number of these lights represents the stored calls that have been unable to find an unoccupied link to an operator. By observing their number and duration, the Chief Operator can quickly decide what temporary force adjustment should be made to assure a satisfactory answer. An operator's schedule of hours, carefully prepared in accordance with peg counts, will reduce to a minimum the necessity for such temporary adjustments. An aid to the proper counting of calls is provided by automatic peg-count meters mounted in a floor-type cabinet; this may also be seen in Figure 2, to the left of the display panel.

Advantages of New Design

Chief among the benefits to be obtained from the Type 6 Information Board are:

1. Improved service
2. Economy of operation
3. Flexibility
4. Easy access to records

These benefits are tied together, some being partially dependent upon others—for example, Improved service (1) results from Easy access to records (4)—yet each is a feature in itself that results from this particular type of switchboard arrangement. Although there are other benefits they may be classified, in one way or another, under one of the above.

Under "improved service" may be listed the improved first answering time made possible by the automatic selection of an idle operator, as mentioned in the foregoing. Since it is this fea-

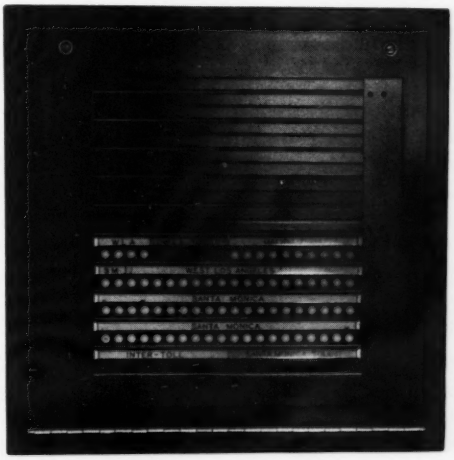

Figure 6. Lamp-signal display panel for Type 6 Information Board indicates the number of calls waiting to be answered.

ture that, with ordinary boards, most often arouses the subscriber's censure, this is a highly desirable improvement. Significant is the fact that service observations made independently of the office management have accredited the office with all index points on "speed of answer to originating calls" since the board has been placed in operation. This has been in spite of a large force turnover and increased force requirement resulting from the assumption of metropolitan toll information.

Also listed here as an improvement over older types of boards is the positive identification of the originating office and class of call. This permits the operator to deal intelligently with each subscriber, with prior knowledge of his location and needs. The link system restricts the number of calls each operator receives at once. Thus she may give her undivided, unhurried attention to each call on an individual basis. On older types of boards, where all unanswered signals appear, a group of waiting signals is apt to cause the operator to become nervous and irritable, with a consequent deterioration of the quality of service.

From the standpoint of economy of operation, the desirability of the electrical arrangement that apportions calls to idle operators in order of their origination cannot be questioned. While this is no "speed-up" system, it assures that each operator must remain occupied as long as she is plugged into a position and there are calls to be answered. It therefore does away with the old complaint sometimes heard from an operator that "I do twice as much work as she but we each get the same pay." Further, it does away with the need for balancing trunk appearances between positions, which is always a problem in large installations of older types of boards. The Santa Monica installation does not lend itself readily to a comparison with the replaced board in the matter of load or units-per-employee-hour for the principal reason that, in the case of the old board, information was given from rotary visible indexed files, while at the Type 6 Information Board printed directories are used exclusively—and the latter requires more operator's time. Also, at the new board, toll information requested requires reference to six printed volumes; the "search time" is therefore necessarily longer. Nevertheless, comparisons with other older types of boards show that a higher load may be carried by the new Type 6 Information Board.

Economy of floor space, made possible by the double-sided Type 6 Information Board, also is a point which cannot be ignored, since it permits installation in locations which in the case of a single-sided desk would require, in many cases, the construction of a specially designed room and the duplication of certain reference records.

The design features of the Type 6 Information Board which make it flexible have already been named. These include the provision for the assignment of various types of traffic to positions by operation of the class-of-call turn keys, the provision for establishing a connection or dialing out, the provision for a preference selection of an operator by class of call, the providing of two links (or access trunks) to the operator so that if one is in use the other may be used, the arrangement for handling supervisor calls so that they do not tie up an operator, and—last in order but foremost in importance—the automatic selection of an idle operator.

A more efficient accessibility to records than has been achieved with this installation is difficult to envision where the use of printed directories is required (see Figure 1). Although a change of focal distance is required by the pile-up of directories, no cases of eye strain due to this cause have been observed. Smaller and less frequently used records are easily identified and obtained with a minimum of effort from their location on the shelf facing the operators.

General Telephone Company's experience with Automatic Electric's Type 6 Information Board has been entirely favorable—so much so, in fact, that similar boards have been ordered for Redondo Beach, Long Beach, and Downey, California, while still another one is in the planning stage for Covina. It is believed that from all standpoints, but particularly that of good service, this board will meet exacting requirements.

COMMON CONTROL AND THE STROWGER SYSTEM*

By C. F. FFOLLIOTT
Director, Product Design Section, Automatic Electric Company

SYNOPSIS: *Strowger System and integration of Independent companies in nationwide toll dialing network — toll switching — common control — common control toll switching — subscriber toll dialing.*

THERE are over 18,000 telephone central offices in the United States and of these more than 12,000 are not operated by the Bell System. The Independent offices are owned and operated by about 5500 companies varying in size from a few lines to over a million. In the aggregate they serve about nine million of the over fifty million telephones. By and large, the exchanges of any one Independent operating company are grouped into relatively small networks with no extensive toll line development. Until the last several years the main automatic switching problems with which these companies had to be concerned were those of local area connections. Their toll traffic, both long and short haul, is handled almost entirely by operators at manual or automatic toll boards.

Operator toll dialing is not new. In the years following 1910 a number of extensive operator toll dialing networks were developed by the Independent companies in Ohio and elsewhere. Even in those early days it was possible for an operator in Indianapolis to dial a call to a subscriber in Cleveland through several tandem switching points and without assistance anywhere along the way. The last two or three years have seen the introduction of nationwide subscriber toll dialing as well as the rapid expansion of operator toll dialing. As a result the Independent networks, which previously have been isolated so far as automatic switching is concerned, are now facing the prospect of becoming integrated in the nationwide automatic toll switching network.

The various publications of the Bell System[1] covering the nationwide toll switching plan have all dealt with the larger aspects of the problem, which is natural since the majority of exchanges serving the large population centers and most of the long distance toll lines are operated by the Bell System. The switching problems encountered in this master plan are vastly different from those encountered by Independent companies with only a limited number of trunks to offices outside their own operating areas.

The Bell System papers referred to describe how the problems of alternate routing, four-wire switching, code conversion, etc. are to be dealt with in the large regional and sectional centers which, in the United States, are all located in Bell territory. From the studies Bell engineers have made, they have concluded that crossbar switching, multifrequency pulsing, card translators, common control, etc. will be required to do the job. The Independent engineers reading these papers try to visualize how these unfamiliar methods and elements of equipment will fit into their previously simple operations and are inclined to be overawed by the complexity and apparent expense of the equipment required. In this paper it is proposed to discuss some of these problems from the standpoint of the Independent company.

The Strowger System

In its original conception and execution the Strowger System is a direct dial controlled system. By this we mean that the impulses originated by the dial on the calling subscriber's telephone are used to operate the various switches involved in setting up the required connection. Consequently, when the dial returns to normal after the last digit, the actual speech connection is completed to the called subscriber's line and it is only necessary to wait for the next ringing cycle for the telephone to ring. Here is a fact that is often lost sight of—

*A Conference Paper presented before the Pacific General Meeting of the American Institute of Electrical Engineers, at Vancouver, B. C., September 3, 1953.

so long as we use the present type of dial, operating at ten pulses per second, *no system can be faster than the direct dial controlled Strowger step-by-step system.* Any system that requires the use of register-senders, with or without translation, must necessarily take longer to complete a connection. This same reasoning can be applied to the use of any type of impulsing other than straight decimal when used in a predominately step-by-step network. Since the Strowger switch operates from decimal pulses it is necessary to transform incoming pulses sent on any other basis to decimal pulses before they can be used. This involves a loss of time in setting up the connection. The only advantage in using multi-frequency pulsing, for example, is in situations where the network is predominately crossbar.

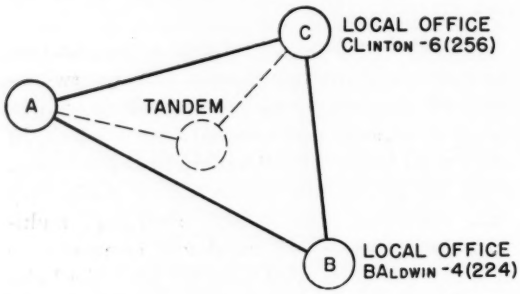

Figure 1. Trunking Scheme With a Tandem Office.

The straightforward method of Strowger trunking is well known and need not be discussed here. It has proved itself capable of handling most of the trunking situations found in local switching networks. This is attested to by the thousands of Strowger networks now in operation.

As the size of a network increases, the desirability of a universal numbering plan increases until in the ultimate, a nationwide network, it is a necessity. The Bell System has adopted the 2-5 numbering plan for local use in conjunction with the nationwide dialing plan. As is well known, each subscriber's number in this plan consists of an office code of two letters and one digit, and a terminal number of four digits (BAldwin 4-1234). However, many exchanges have no need of seven digits for their local switching and the use of the 2-5 plan introduces problems.

Closely associated with the numbering plan is the use of destination codes instead of route codes. A destination code, as its name implies, is one that simply represents the location of the office in question, but does not necessarily represent the route by which it is reached. A route code, on the other hand, tells nothing about the location of the office, but gives instead specific directions for reaching it. Under universal numbering, the destination code of an office is always the same regardless of the starting point. The route code may be different for each different starting point. In the nationwide dialing plan a destination code may require translation into a route code at very large control switching points to reach the called party. In the networks with which the Independent is more concerned a carefully laid out trunking plan will allow the use of destination and route codes that are identical.

The Strowger System—Toll Switching

A typical layout for a small network in which these problems arise is shown in Figure 1. Let us assume that A, B, and C are small offices in a direct dial controlled network. Office B is called BAldwin 4 and office C is CLinton 6. The numerical equivalents of these office names are 224 and 256 respectively. The trunking layout of this network should be arranged so that all the subscribers in all the towns will always dial the same number to reach any given subscriber in the same or adjacent towns; i.e., the telephone numbers are universal throughout the area. Figure 2 shows a trunking layout for this network and for simplicity the trunking is shown in one direction only, from A to B and C. It is obvious that similar arrangements can be made in the other directions as well. Each of the towns is equipped with digit-absorbing selectors. Selectors of this type have been used for many years in the Strowger System, and their application to the 2-5 numbering is simply an extension of an old technique. The selector for this application is called the 2-5 selector and it is arranged to absorb repeatedly whenever certain levels are dialed, and to absorb and unlock the restricted levels whenever certain other levels are dialed. In Figure 2 ***AR*** designates "absorbed repeatedly" levels. This particular layout does not require unlock levels. For a subscriber in A to reach someone in B, he dials BA4 (224). Since 2 is an ***AR*** level

the switch drops back each time it is dialed. He then dials 4, and the switch cuts through to town B, where the last four digits of the terminal number are used to reach the subscriber. The same procedure is used to reach someone in C. In this case the subscriber dials CL6 (256). Since 2 and 5 are both *AR* levels the switch restores after each of the first two digits. Finally, on level 6 it cuts through to C, and the call is completed.

Now suppose for some reason it is uneconomical to trunk directly from A to C, and we want to route all calls to C through a tandem. This can be done by rearranging the trunking at A. In this case the *AR* is removed from level 5, which is trunked directly to tandem as shown dotted. The 6 level from tandem is trunked to C, and we still retain our universal numbering.

By extensions of the above example it can be seen that the application of 2-5 selectors will solve many of the short-haul toll problems of Independent companies without resorting to the use of common control equipment such as registers, translators and senders. The use of this selector has another feature which was not mentioned above but which is very desirable. None of the areas shown in the example need seven digits for local switching. By using the 2-5 selector subscribers do not have to dial seven digits for local calls unless they want to. For instance, to get to C from A, the CL can be omitted from the office code since level 6 is a cut through level. The same is true of B. The importance of this feature is that nationwide the numbering plan is 2-5, but locally it is only a five-digit system.

The Strowger System—Common Control

The problems of an Independent company operating in a metropolitan network which uses a register-translator-sender system are somewhat more complicated. The chances are that a simple trunking layout is not possible and that some form of common control and code conversion must be used. Although the Strowger system was conceived and designed as a direct dial controlled system, its extreme versatility was demonstrated in 1923 with the development of the Strowger Director system for use in London, England. The Director is a register-translator-sender applied to the Strowger system. The engineers of the British Post Office made a very extensive study of all existing systems of switching, including those in which common control is an inherent feature, and chose the Director as being the most suitable and economical.

It is interesting to note that in his inaugural address as president of the Institution of Electrical Engineers on October 5, 1950, the Engineer-in-chief of the British Post Office, Sir Archibald Gill, reviewed the progress made in Great Britain since the adoption of the Director system in 1925. In particular he said, "It is true that in the interval other systems have been evolved—some suited to large cities and others to smaller communities. Some of the newer systems have particular advantages such as greater availability on their switches or speedier operation. None, however, has the simplicity and the universality of the step-by-step system, which allows the same components and the same circuits to be used in the smallest and the largest exchanges. Thus it is probable that if a similar decision had to be made today the choice would be the same as it was 25 years ago."

The Strowger System—Common Control Toll Switching

There are at present five Director installations[2] in the United States. Three are in the metropolitan Los Angeles area and two in the metropolitan Chicago area. These installations have demonstrated conclusively that the Strowger system with the Director is capable of handling any large network problem. One feature of these systems that has not been sufficiently stressed in the previous papers is that the equipment units making up the Director utilize exactly the same types of components as those which make up the ordinary Strowger office. Although the circuits are, of course, somewhat more complicated, they are nevertheless straightforward and easy to understand. Maintenance is not complicated by new types of apparatus or complex circuit techniques when Director operation is introduced. The calls are still advanced step-by-step the same as in the non-Director Strowger system.

The Director installations mentioned were designed primarily for use with metropolitan area dialing in mind. However, the system is so flexible

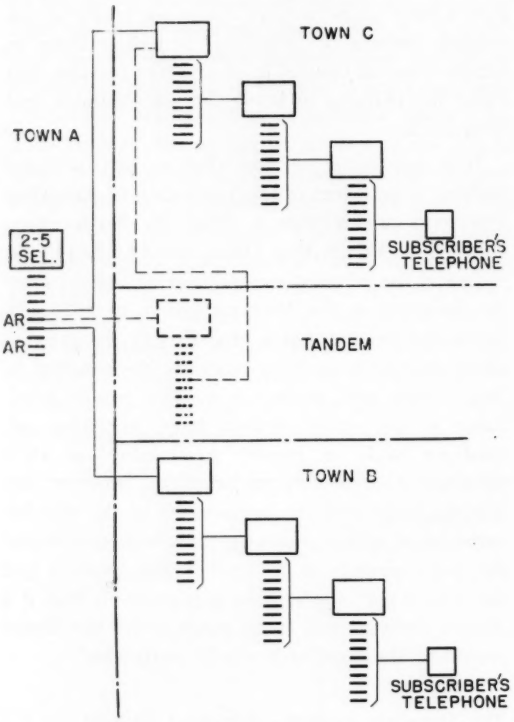

Figure 2. Switching Diagram for Figure 1.

that the addition of a single unit to each Director without any changes in existing circuits will make it suitable for use in the nationwide dialing scheme.

In exchanges that require the use of Directors, alternate routing can be provided automatically by the Directors so as to achieve the same degree of economy in outside plant construction as is possible with any type of alternate trunking equipment. However, in exchanges that have no other use for them, Directors would be an unnecessary expense if used simply to provide alternate routing. A study we have made of a number of typical exchanges with several trunk routes has shown that in most cases none of the routes has any possibility for alternate routing. In some cases there was a possibility that a few of the trunk groups might use an alternate route. It is obviously wasteful of money and switching time to install Directors to handle all the toll traffic because a very small percentage may require alternate routing. Here is another situation that dramatically demonstrates the flexibility of the Strowger step-by-step system. Assume that in one trunk group there is a possibility of alternate routing. Figure 3 shows the basic layout of a plan that allows alternate routing in that group. The direct trunks to A are reached by dialing the proper destination code. If, however, the direct trunks are all busy, the switch rotates into the overflow group which reaches A via an alternate route through B. The overflow contacts are connected to alternate route translator relay groups. Since the relay groups are individual to the particular trunk group in question, the necessary translation to produce the routing digits to reach A by an alternate route—or any of several alternate routes, if desired—is permanently built in. Storage to provide the delay required to route the call through B (or for that matter through several tandem offices) is introduced by an inexpensive Director which can be common to all the different trunk routes for which alternates are available. When the connection is completed to A the Director sends the stored digits and the call is completed.

The example discussed in the preceding paragraph is a very striking illustration of the statement made earlier that "there is nothing faster than direct dialing by the Strowger step-by-step system". When the call is made to A by direct trunk, the connection is completed immediately after the receipt of the last series of impulses. However, when

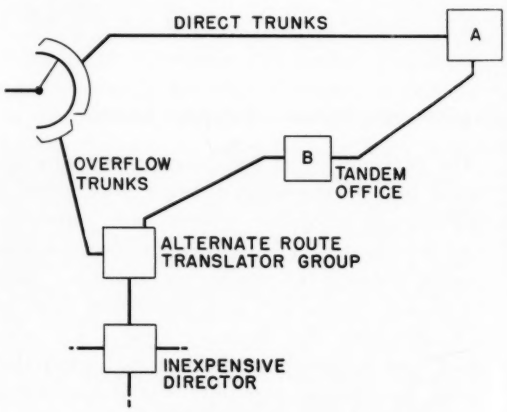

Figure 3. Simple Alternate Routing Plan.

it becomes necessary to introduce the translator group to provide alternate routing, some delay is introduced and the connection is not completed until several seconds after the last series of impulses have been received. This example illustrates another striking feature of the step-by-step system in its relation to common control—the ability to "take it or leave it". When you need common control, you put it in; when you do not need common control, you leave it out; if the common control is not needed in the original installation, it is omitted at that time; if a need for common control later develops, it can be added without any modification of the original installation or the other trunk groups not requiring its use. In most cases common control would be required on only a small number of the routes and even on those only a fraction of the traffic will make actual use of it. Therefore, the common control equipment need be provided to serve only a fraction of a fraction of the traffic, and only that amount of traffic need be delayed by storage and translation.

The Strowger System—Subscriber Toll Dialing

Thus far this paper has dealt primarily with the problems of toll switching, and since nothing has been said about recording toll charges, it has been tacitly assumed to be operator toll dialing. The success of the Bell System's Englewood experiment has brought nationwide subscriber toll dialing very much to the fore, and many of the Independent operating companies are wondering how they can join the network. There are four basic requirements. First, they must be able automatically to record all the call data for billing purposes. Second, they must have switching equipment capable of handling the ten or eleven digits required by the national scheme. Third, they must use the 2-5 numbering plan in order to receive incoming calls. And fourth, they must provide the proper supervisory signals.

Systems using step-by-step equipment which meet these requirements have been described in other papers, so they need not be discussed in detail here. The first requirement is met by the SATT (Strowger Automatic Toll Ticketing) system. The SATT system is a means of recording charges incurred by a subscriber in making a toll call. Although the five exchanges already equipped for SATT operation are using it for metropolitan traffic only, the design is such that it can be expanded to nationwide service with a minimum amount of additional equipment.

There are at present four types of the SATT system. Type A is the most complete. It includes the Director, automatic detection of the calling subscriber's number, and complete recording facilities. It is intended for large offices. The type B system is the same as the type A except that the Director is omitted. This means that a calling subscriber must dial a toll access code and routing digits to reach his destination. Detection and recording are automatic. The type B system is intended for any size office in which all calls within a local area can be completed under direct dial control. It is also possible to make simple translations. The type C system is the first of the simplified systems intended for networks of small automatic exchanges. In this system both the Director and the detector have been omitted. In order to identify the calling party he must dial his own number first. The system is equipped with a verifier that checks the number dialed and if not correct, blocks further progress of the call. Information recording is as in the other systems. Finally there is the type D system. In this system the call is intercepted by an operator who ascertains the calling party's number and registers it into the system by means of a keyset. The call then proceeds as in the other systems.

The call information in SATT systems of all types is recorded by a four element code perforated in telegraph tape. It can be processed in either of two ways. The first is to produce business machine cards for further processing in any of the standard punched card machines. This method produces completed bills. The second is to print tickets from the tape and to process the tickets manually in the normal manner. An additional step can be added to this method. It is possible to build into the printing equipment a computer that will calculate the total charges and print the result on the ticket.

The second of the basic requirements for joining the nationwide subscriber toll dialing network can be met by the application of the Director or by the skillful use of 2-5 selectors. The third requirement, the use of the 2-5 numbering plan, does

not require further comment. The last requirement, that of the proper supervisory signals, can be met by any properly designed system and is no problem.

Conclusion

The nationwide subscriber toll dialing plan of the Bell System can certainly be considered the ultimate in telephone service. The engineers of the Bell Telephone Laboratories deserve a great deal of credit for the thoroughness with which they have analyzed the problems involved and the simplicity of the basic solution they have proposed.

The United States and Canada are blessed with a unified telephone system that is without equal anywhere else in the world. Our superb system is the result of the splendid cooperation and coordination that exists between the multitudinous Independent companies and the Bell System.

For the nationwide subscriber toll dialing system to reach its ultimate usefulness it must be extended to the Independent companies. This paper has shown that the problems most of the Independent companies will encounter in joining the nationwide subscriber toll dialing network can be solved by using equipment and techniques with which they are already familiar. They have no reason to be concerned or worried about the problems of the master plan which have been discussed by the Bell System and which will be dealt with by them. The only concerns of the Independents are to provide themselves with switching equipment that will complete a connection to a Bell control switching point and transmit to it the area code and local number of the called party, and to adopt a numbering scheme which will conform with the nationwide plan. From there on the problems in the main belong to the Bell System.

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THE PLACE OF "2-5" SELECTORS IN NATIONWIDE TOLL DIALING

By L. L. RUGGLES
Chief Telephone Engineer, Automatic Electric Company

SYNOPSIS: Necessity for "2-5" selector — features — functions and characteristics — examples — summary.

THE advent of nationwide toll dialing—operator and subscriber—will necessitate universal "2-5" numbering. By "universal numbering" is meant a numbering plan in which the number to be dialed to reach any given station is the same regardless of the point of origin of the call in the area covered by that numbering plan. Therefore, when universal "2-5" numbering covers the entire United States, many telephone companies will be required to use seven-digit numbers in exchanges which would normally use only four or five digits. With the new "2-5" selector switch Strowger Automatic exchanges can convert simply and economically to the seven-digit numbering plan required for Nationwide Subscriber Toll Dialing.

The "2-5" numbering system will require that all subscribers' dials be equipped with numbered and lettered number plates. Applying a "2-5" number system to a central office that has a switch train which is capable of completing a connection on four or five digits will require one of two provisions to insure the completion of a call by the use of seven digits.

1. Extra switch trains must be provided in the train to utilize the digits dialed or,
2. A first selector which will absorb two or more digits that are not needed for switching purposes.

To meet this need, Automatic Electric Company manufactures a variety of selectors capable of absorbing (cancelling) two or more digits not required for switching purposes, with or without line lockout and conversion timing.

Features

By *repeated absorption* of digits, the "2-5" switch does the work of several costly ranks of switches which would otherwise be required, and effects a substantial savings in equipment.

One of the most important features of the "2-5" switch is that levels representing *absorbed digits* in the office code can also be used for local area switching. The "2-5" switch thus gives full use of all levels for active trunk groups.

These selectors also can perform many intricate switching operations required in short-haul toll networks and thereby eliminate the need for costly common control equipment such as registers, translators, and senders. In a network of local exchanges, the "2-5" switch permits using a universal directory for local calling as well as for calling into adjacent areas on an extended-area basis.

In an existing automatic telephone system, which may some day be involved in customer toll dialing, existing first selectors may be replaced by "2-5" selectors to accomplish the necessary expansion of the numbering system to seven digits. Generally speaking, the first selectors which are replaced may be used as second or third selectors in an expansion program, thus making the cost of the conversion consistent with the benefits derived. For this reason it is suggested that when planning additions to an existing exchange, "2-5" selectors be purchased for all requirements. These "2-5" selectors may be used to replace existing first selectors, and the first selectors used for expansion of the local switch train wherever possible.

It is assumed that most telephone companies will choose to participate in the program, and it is therefore recommended that for new exchanges plans be made to procure "2-5" selectors where needed to implement the "2-5" numbering system which may be adopted later, if not at the initial service date.

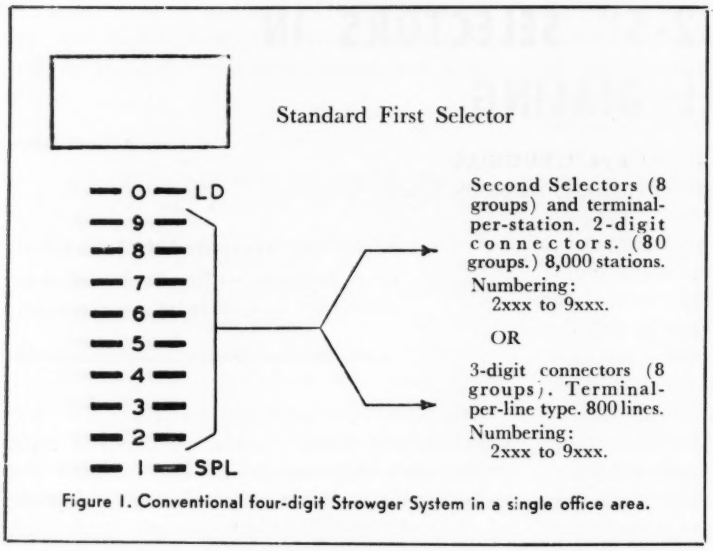


Figure 1. Conventional four-digit Strowger System in a single office area.

line systems to terminal-per-station operation as conditions permit. The advantages are numerous but cannot be detailed here.

The diagrams which follow show methods of expanding a normal four-digit system into a five-digit system or a "2-5" system. The local switching groups in each system are the same, except for the first selectors which show a variation from a standard first selector to digit absorbing types which have been used in the past, and finally a "2-5" selector which is discussed more fully later.

Figure 1 illustrates a conventional four-digit system which accommodates either 800 lines on a terminal-per-line basis with one rank of first selectors and eight groups of connectors, or 8,000 stations on a terminal-per-station basis.

Figure 2 shows the same type of switch trains

Function and Operation

Basic functions and operating characteristics may be illustrated by a series of simple diagrams. These diagrams do not attempt to show complete switch trains since there are many variations of switching plans to meet local conditions. Only the first or primary selector is illustrated, with indications of the succeeding switch trains required to select decimal groups in accordance with varying sizes of exchanges.

Both terminal-per-line and terminal-per-station systems are illustrated. For all new exchanges it is recommended that terminal-per-station equipment be seriously considered because of its more efficient use of office codes. Each office code, consisting of two letters and the first numeral digit, for example HA-2, will serve only one thousand lines in a terminal-per-line system; while in a terminal-per-station system one code will serve ten thousand stations or directory numbers. Some companies are planning to convert terminal-per-

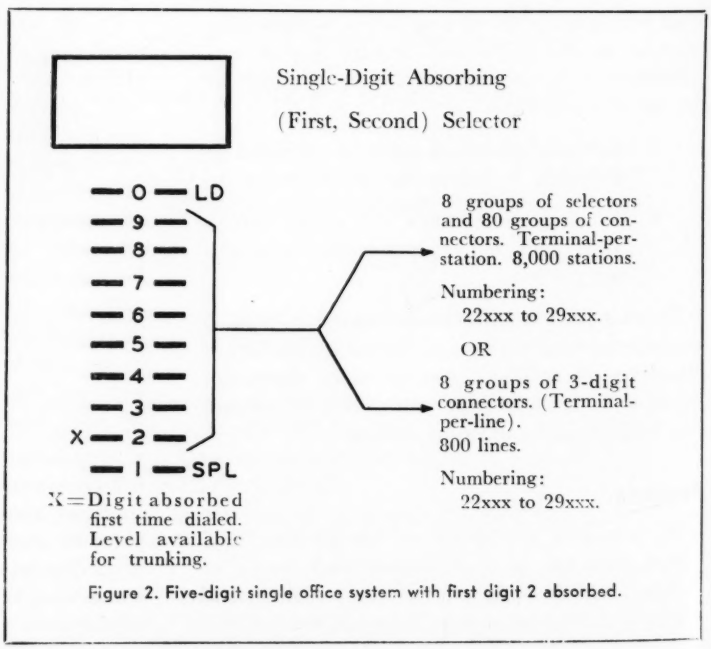


Figure 2. Five-digit single office system with first digit 2 absorbed.

as Figure 1, except for the first selector, which is arranged to absorb the first digit *2* the first time it is dialed. This is the familiar pattern frequently used to allow a system which normally uses four digits to use five-digit directory numbers.

Figure 3 illustrates a normal four-digit system having switch trains capable of selecting subscribers' numbers on the final four digits of a seven-digit "2-5" number plan. This plan uses the same switch trains as in Figures 1 and 2, with the same line or station capacity, except that the first selector in Figure 3 is a "2-5" type selector. It will absorb the first three digits *432* and will select a trunk to a succeeding switch on *any* fourth digit, including trunks on levels previously marked for absorption.

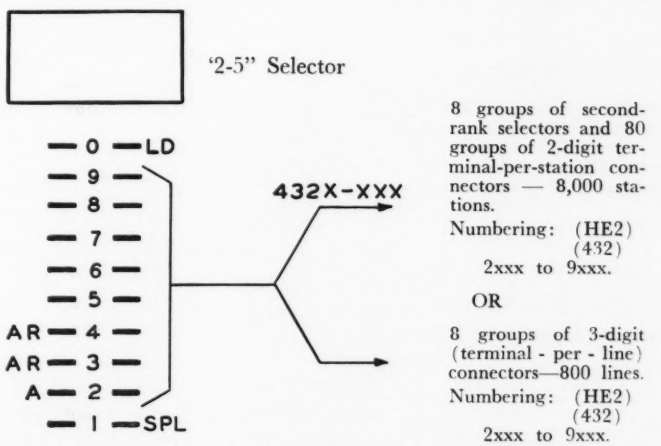
The operating procedure is as follows:

In response to the first digit dialed *4* or *H*, the selector steps to level 4 which is marked AR, meaning "absorb repeatedly." The switch will release because the shaft spring contacts are adjusted to close on level 4, and will then respond to digit *3* or *E*, by stepping to level 3 (also marked AR) and again restore to normal position. The third digit dialed *2* will step the selector shaft to level 2 (marked A, meaning "absorb"). Again the switch will restore, but shaft springs adjusted to operate on level 2 (marked A) will not only restore the switch, but will also *remove all markings from all levels* and permit the switch to select a trunk on the next or fourth digit on any level regardless of previous markings. Thus all levels are available for trunking groups after digit *2* is dialed.

From this example it is apparent that even though a directory number may be seven digits for purposes of nationwide numbering, a local subscriber may reach any local number desired using only the last five digits (22xxx to 29xxx).

For single office areas it is sometimes suggested that subscribers be advised of the possibility of dialing only the five numerical digits to call numbers in the *single* office even though the directory may list seven-digit ("2-5") numbers. For multi-office areas it does not appear as desirable because a seven-digit number will be required to complete calls from one office to another. This practice may not always be feasible, and is dependent upon suitable office codes and trunking arrangements best fitted to the local area.

Figure 4 shows a first selector in one office of a multi-office system. The local office code is HE-2, and the last four digits may be in the 2xxx series.



AR = Absorb repeatedly until unlocked by A digit.
A = Absorb and unlock (remove markings from all levels), making all levels available for trunking.

Figure 3. "2-5" Type system using digit-absorbing ("2-5") selectors in a single office area.

The operation on local calling will correspond to that described for Figure 3. The local switch train would consist of second rank selectors and 10 groups of terminal-per-station connectors, or a single group of three-digit connectors. The first arrangement would serve 1000 stations on a terminal-per-station basis, but only 100 lines on a terminal-per-line basis. Under normal loading of party lines, the latter system might accommodate only 300 or 400 subscribers. This contrasts with 1000 subscribers served by the same code (HE-2) and directory numbering HE2-2xxx.

Figure 4 also illustrates a few of the operating features which may be required in a multi-office area where several non-related codes may be assigned.

Examples

(1) Level 2 trunks to the local exchange on the fourth digit *2*, as explained.

(2) Level 3 trunks to an office having code 423, for example HA-3.

This is accomplished by means explained above and the results are as follows:

(a) First digit *4*—absorbed.

(b) Second digit *2*—absorbed, causing level 3 to become available for trunks.

(c) Third digit *3*—selects trunk on level 3.

(3) Level 4 trunks to an office with code 324.

(a) First digit *3*—absorbed.

(b) Second digit *2*—absorbed, causing level 4 to be available for trunking.

(4) Level 7—code 327.

(a) First digit *3*—absorbed.

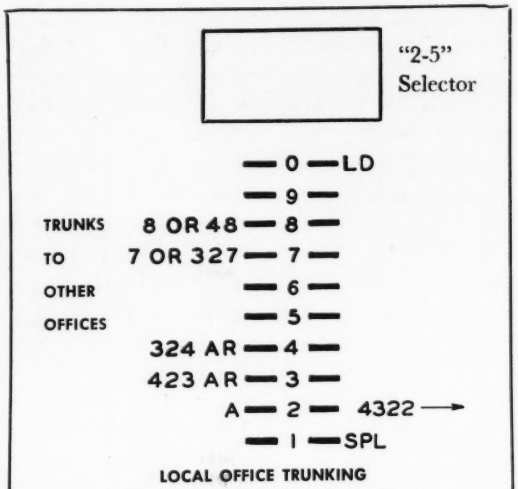
(b) Second digit *2*—absorbed.

(c) Third digit *7* to trunks. Level 7 could also be reached by a first digit *7* without previously dialed digits, since it has no markings.

(5) Level 8—code 48.

In this case *4* is absorbed, and *8* selects a trunk. Such a plan would presumably use five digits in tandem or terminating offices.

If *8* were dialed first to reach level 8, the remaining six digits could be used for tandem or termination trunking as required



LOCAL OFFICE TRUNKING

Additional rank of selectors and connectors for local office stations. Terminal-per-station.

Numbering: (HE2) 2xxx
(432)
1,000 stations
(or 100 lines Terminal-per-line.)

AR = Absorb repeatedly until unlocked by A digit.
A = Absorb and unlock (remove markings from all levels), making all levels available for trunking.

Figure 4. Multi-office system with "2-5" numbering. Only one office is shown.

These examples should be considered only typical since the codes illustrated, or any combination of them, may or may not be available for assignment to a particular exchange. Availability of codes may be a limiting factor in trunking arrangements or in switch capability. Consultation with the associated Bell Telephone Company representative in the territory is suggested well in advance of final planning. Early assignment of codes for the area is advantageous to all concerned.

Summary

The "2-5" selector is an economical and convenient switch for implementing the "2-5" numbering plan which is a requirement for nationwide subscriber and operator toll dialing.

Terminal-per-station operation is preferred over terminal-per-line operation for all systems because of its more efficient use of office codes, the use of local numbers, the flexibility of trunking, and the facility for intercept.

THE ACCURACY OF SWITCH PEG COUNT METHODS

By IMRE MOLNAR
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SYNOPSIS: *Calling rate measurement of various components — peg count meters — magnitude of lost peg counts — probabilities of simultaneous switch releases — Poisson summations — reliability of switch peg counts.*

ONE of the fundamental quantities of interest in any traffic study is the calling rate of various components. If we take as an example the traffic observations on Strowger type selectors, the number of calls passing through them during a certain time interval—for instance, during the busy hour—has to be determined. After each use, a Strowger selector is returned to its normal position through operation of its release magnet. Therefore the most convenient method of obtaining the calling rate of a selector is to count the number of times its release magnet is energized during the period of observation.

Since it is not feasible to provide an individual counter for each selector, it is the usual practice to count the aggregate number of releases in a group of selectors. This can very easily be done through use of existing provisions, as shown in Figure 1. The battery terminals of the release magnets on a shelf of selectors are connected together and to a common battery feed relay, designated *RLS*. Usually there is one *RLS* relay for ten selectors, though one is sometimes assigned to a whole shelf of 20. The principal function of this relay is to provide an alarm signal if a selector does not release. In this case, the release magnet and the *RLS* relay are energized for a prolonged length of time, since this circuit is normally interrupted only after the switch restores to normal and opens its associated off-normal springs.

Switch Peg Count Meter

Since an *RLS* relay operates each time one of the associated selectors releases, a pair of springs on that relay may be used to actuate a "peg count" meter, and the meter will indicate the number of calls going through that group of selectors. It will be noticed that the *RLS* relay is slow to release, so as to insure a full pulse to the peg count meter, even though the release magnet is only briefly energized, as is the case, for instance, when the switch releases from the first contact of its first level.

The question immediately arises: what happens if two or more switches release simultaneously? Obviously, each time this occurs there will be a deficit of one or more counts. Such questions are usually answered in one of two ways: some express the opinion that lost counts occur so rarely that they can be neglected in the peg count; others feel that because of these lost counts, the peg counts would be so far off as to make the entire traffic study useless. The question, therefore, is to find out whether or not lost counts are really negligible, and if not, what correction should be applied.

Magnitude of Lost Peg Counts

The purpose of the following analysis is to determine the magnitude of such lost counts under extremely severe conditions, and to suggest what allowance, if any, should be made under whatever conditions exist.

Let us first try to find the number of releases during one hour on a shelf of 20 selectors, having a common relay designated *RLS*. From the standard traffic capacity table we learn that the maximum conceivable amount of traffic 20 selectors could handle is about 650 unit calls, but only under the assumption that these selectors happen to be first choices from a preceding rank—something which normally would be avoided by proper allocation of the selectors. If we assume an average

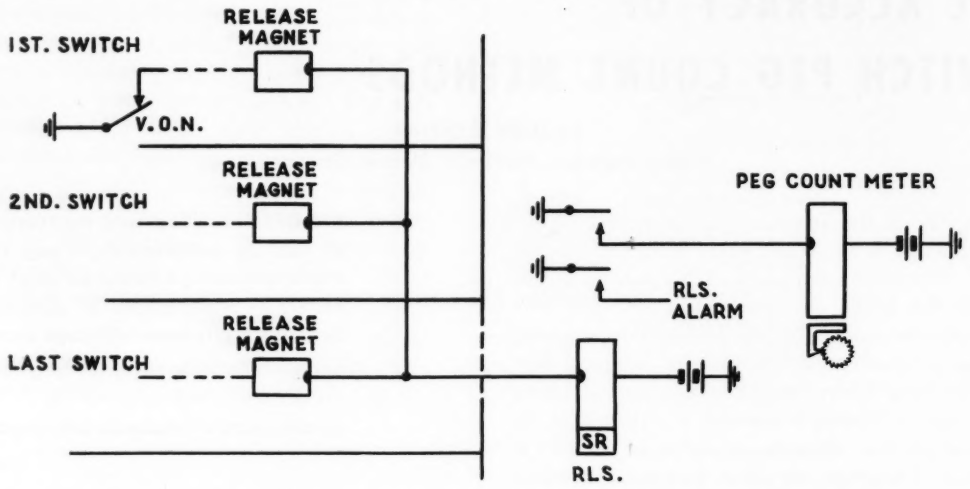

Figure 1. Peg counts from switch release operation.

duration of 120 seconds per call, the calling rate per busy hour will be 540 for a group of 20 switches, or 27 per switch. We will designate the calling rate for a group of switches N, and the calling rate per switch as n.

We know that 0.150 second elapses from the time the ground potential is applied to the release magnet until it opens its vertical off-normal contacts, provided the switch releases from the tenth contact of the tenth level—the most unfavorable place for the purpose of this analysis. If we allow another 0.100 second for the release of the *RLS* relay and the peg count meter, the total of 0.250 second, which we now call g, will cover the longest possible release time encountered.

Probabilities of Simultaneous Switch Releases

Each time two switches release simultaneously within the interval g we are losing one count; each time three switches release during such interval we are losing two counts, etc., up to the possibility of all 20 switches releasing simultaneously, when we would lose 19 counts. What we want to find out, therefore, are the separate probabilities of two switches, three switches, and so on up to 20 switches, all releasing simultaneously within the interval g. Moreover, if one switch releases so that a portion of its release time partially overlaps the release time of another one, we have counted one release only, although two switches released; and this deficiency continues up to the point that the release of the second switch begins immediately before the *RLS* relay restores at the end of the release action of the first switch. Therefore, the period to be considered is not g, but $3g$. These considerations may be extended for three, four, etc., consecutive and overlapping releases.

The mathematical procedure was developed by the author*, applying a modified version of Bernonilli's theory. It was shown therein that in one hour's observation of 540 releases only 0.72 of one count would be missed.

In the present article a considerably simpler though somewhat less exact approach will be shown. Compared to an hour, the duration of a release is apparently very short. The distribution of such rare events as simultaneous switch releases is sufficiently well defined by Poisson's law. According to this law, the probability of z events taking place simultaneously is

$$e^{-y}\left(\frac{y^z}{z!}\right)$$

*A STUDY OF TRAFFIC IN AUTOMATIC TOLL TELEPHONE SYSTEMS. Imre Molnar. Part II, page 2-27. Northwestern University, Evanston, Illinois, 1950.

where y is the Poisson parameter. In our case the events are switch releases; therefore, the above expression represents the probability that 1, 2, 3, etc., switches will release simultaneously, and therefore the probability that 0, 1, 2, etc., peg counts were missed. Poisson's law has the advantage that it depends only on a single parameter y and furthermore that it is extensively tabulated. It remains now to determine the value of y for our application.

The release time of one switch was designated as g. In order that a deficit could occur, the release times of at least two switches are involved, which may completely or only partially overlap. Neglecting the possibility of a chain of more than two successive releases, it seems to be reasonable to assume a virtual duration of $2g$ for the event. The validity of this point of view will become more apparent from the considerations which follow.

Choose an arbitrary moment x during the period of observation, and assume that a particular switch is in the process of releasing. Since the release periods are assumed to be constant and equal to g, the point x must lie within an interval AB of the length g (see Figure 2). The problem is in no

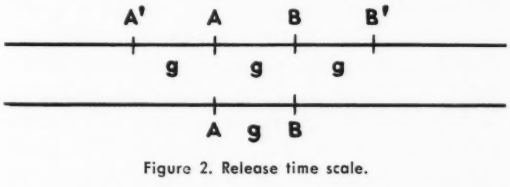

Figure 2. Release time scale.

way restricted if we assume that x actually coincides with A. If another switch releases within an interval $A'B'$, where $A'A = AB = BB' = g$, and where, therefore, $A'B' = 3g$, only one count is made for two events, since the release times of the two switches either overlap or are continuous. Therefore an error of —1 is made in the peg count. The problem now is to find the probability that a second switch will release within an interval $3g$, if we know that one is being released during the center portion of the same interval. Since the release times g are all equal, the probability will be the same as the probability that a second switch will start to release between the points $A'B$ (or between $x—g$ and $x+g$), if it is known that one switch is starting to release at x.

There are s switches, with a total of N releases during an observational period (which may or may not be one hour). That is an average $N/s = n$ releases per switch, each release having the exact duration g expressed by taking the total observation time as a unit. Thus one switch, on the average, will be found in the process of releasing during ng of the total observation time. If we examine the switch during an interval L, we find it, on the average over a very large number of examinations, to be releasing during Lng of the time. We now call

$$p = ng = Ng/s$$

the fundamental probability of the event of releasing by one switch. From what we have said above, the probability $P(L)$ of finding one switch releasing during an interval L is Lp; and, therefore, the probability $P(x, x+dx)$ of releasing during dx is pdx. Furthermore, if, for instance, we found the probability of a switch releasing at the instant x, we have simultaneously found the probability that the switch is in the process of releasing during an interval g, which includes the point x, and this latter probability is obviously pg. Moreover, the same probability also determines the probability that a switch starts to release at an instant x. Therefore, if we ask for the probability of finding a switch releasing at x, we are at the same time asking for the probability of releasing during g about x, or for the probability of releasing during interval $(x, x+g)$, which is the same.

Let us now again choose the arbitrary point A at x, which also means that we have chosen the interval AB of the length g. We are asking for the probability p^* *as referred to point* A—this may be designated as $p^*(x)$ or, what is the same, the probability gp^* *as referred to the interval* AB that the interval $A'B'$ of length $3g$ includes the complete release process of a certain switch. This is equivalent to the requirement that a second switch starts to release in the interval $x—g$ and $x+g$, if it is known that a first switch is starting to release at x. As a matter of fact, this second probability is the same whether there is such a first switch or not, and is represented by

$$p^*g = \int_{x-g}^{x+g} pdx = 2pg$$

or

$$p^* = 2p$$

Thus the probability p^*, *as referred to point* x, that a switch is starting to release within an interval $x-g$ and $x+g$, is twice the probability p that a switch is starting to release at a point x; or, in other words, that the release action which takes place within an interval $3g$ has twice the probability of release action taking place within an interval g.

In our case, therefore, the parameter y of the Poisson equation will be

$$sp^* = 2Ng = 2 \times 540 \times 0.250/3600 = 0.0750$$

The Poisson Summation

The best available tables for the Poisson function can be found in *Poisson's Exponential Binomial Limit* by E. C. Molina. Using Table I, we obtain the following values:

z		
1	0.06956	0.00000
2	0.00261	0.00261
3	0.00007	0.00014
4	0.00000	0.00000

The first column represents z, the simultaneous events taking place. Although it should have been extended to 20 simultaneous releases, it is broken off after four, since the corresponding probabilities would be beyond the lowest significant figure for which Molina's tables were computed. The second column represents the probability for the corresponding event to take place, obtained by interpolating Molina's values for $y = 0.07$ and $y = 0.08$. The third column is obtained by multiplying the values of the second column by $z-1$, and represents the corresponding expectation for a deficit. The sum of the third column, 0.0275, is the proportion of counts lost. For 540 releases the total deficit will thus be 1.48 counts missed.

Reliability of Switch Peg Counts

This figure is about twice as high as that obtained by the more exact approach; however, considering the ease with which it can be computed, and also that we are only interested in the order of magnitude of the maximum conceivable error in peg counts, it appears to be a very useful method for the analysis of such problems. We may, therefore, conclude that under extremely severe conditions we may miss one count in each observation hour, and perhaps one additional count every three observation hours.

For the computation of the minimum deficit, let us assume two counters for a shelf of 20 switches and the shortest conceivable interval g which is about 0.1 seconds (releasing from the first contact of the first level). We will find that in a one hour observation of 540 releases only 0.058 of one count would be missed, or only one count in 17 hours of observation, a truly negligible error. But even the maximum conceivable amount of deficit, which is on the order of 0.3%, need not cause any worry. A study of telephone traffic with the aid of mathematical statistics clearly indicates that a very prolonged observation program, extending over a hundred or more busy hours, may not provide us with a figure for the traffic accurate to a fraction of 1%; and therefore the application of a correcting factor for the mechanical shortcomings of the peg count procedure would not be worthwhile.

REVERTING-TYPE CALLS IN AN AUTOMATIC TELEPHONE SYSTEM

By EDWARD J. GLENNER
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SYNOPSIS: *Reverting-call requirements—methods of signaling—types of reverting-call systems—circuit description — miscellaneous factors.*

AN important factor contributing to the rapid growth of telephone service in the United States has been the party line. Multi-party lines make telephone service economically feasible for the greatest number of people by reducing appreciably the outside and inside plant cost per subscriber. The economies become rather obvious when it is seen that a single pair of conductors may be extended several miles, and then be connected to four, five, ten, or in some instances as many as twenty subscriber stations. Such a line is terminated at the central office on a single set of line equipment through a single set of protective facilities. In contrast to this, if each station had its individual line the pair of wires serving each station would have to be brought to the central office and terminated through protective equipment, on line equipment that is used for that one station only.

While providing a marked saving in equipment cost, the party line introduced certain technical problems that had to be overcome before the system could be effectively utilized. One problem was to provide some means of establishing a connection between one party-line subscriber and another subscriber on the same line. This type of call is termed a "reverting call" or "revertive call", and automatic equipment designed to establish such a connection is called "reverting-call equipment".

In all but the largest manual systems, a revertive call requires no special equipment, since the operator recognizes the fact that both calling and called parties are on the same party line and, therefore, she merely signals back on that line manually. In an automatic system, however, if a subscriber were to dial another subscriber on the same party line without using special devices, the calling party would find the line busy (since he himself in attempting the call has made it busy), and upon receiving busy tone would hang up and break the connection. A specialized piece of apparatus used for establishing a revertive call is a "reverting-call switch". One type of reverting-call switch is shown in Figure 1.

Reverting Call Requirements

Before continuing with the technical description of reverting-call equipment, it may be well to point out briefly some of the social factors governing its use and utility. Consider first a small rural community with sometimes as many as twenty parties on the line. These subscribers are undoubtedly neighbors who live on adjacent farms and have a high "community of interest". A relatively high percentage of the calls made by a subscriber on such a line would be of the revertive type. The party line of this type is well known for its social function of not only connecting the two desired parties but also enabling other friends on that line to listen in and enter into the conversation if desired. A community of this type therefore requires a relatively large amount of equipment for establishing reverting calls.

In contrast to this, a metropolitan area with a high population density does not necessarily have such a high community of interest and, in many cases, a party line subscriber does not know the other parties on his line. In addition, most of the party lines in large metropolitan areas are limited to merely a few parties. Considering the ratio of the total number of subscribers to the number of parties on an average party line, it is apparent that areas of high population density make a smaller percentage of reverting calls than small rural com-

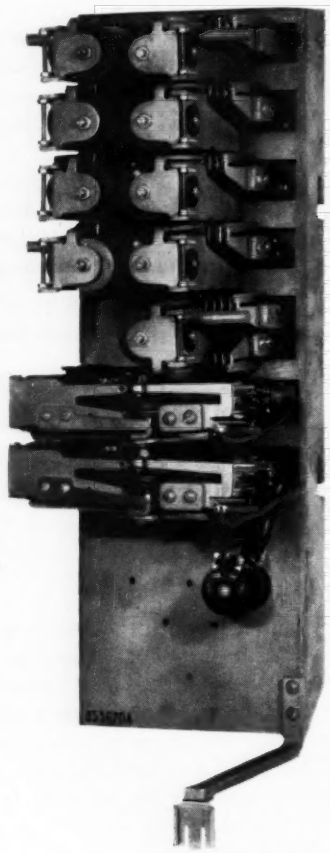


Figure 1. A typical reverting-call switch.

munities—hence, only limited facilities are required for establishing reverting calls. Thus, the number of party lines in itself in relation to the total number of lines in an exchange area does not have as direct a relation to the required amount of reverting-call equipment as might be expected. The *number* of parties on each line is a more important consideration; and the *type* of subscriber served may be of prime importance. In small rural automatic exchanges the amount of reverting calls may be as high as 25% of the total traffic, while in the large metropolitan areas the amount may be less than 1%.

Methods of Signaling

Another problem peculiar to the party line is the need for selective signaling. Some means of party selection has to be provided so that a particular subscriber in a group of subscribers can be informed of an incoming call.

There are several ringing schemes: (1) bridged ringing which may be coded, harmonic selective, or semi-selective (one and two ring); (2) divided ringing—harmonic and combinations of the above ringing schemes serving as many as twenty subscribers per party line; (3) superimposed or "superposed" ringing with biased ringers and divided ringing, accommodating up to four parties on a fully selective basis.

Types of Reverting Call Systems

Reverting Call by Special Number

When the party lines are arranged on a "terminal-per-line" basis, all parties on the same line have similar numbers; only the final digits differ and are used for selecting the proper station on the line. This reverting-call trunking situation is illustrated by Figure 2.

The calling subscriber can easily recognize when a desired party is on his own party line, and by dialing a special prefix (say "119") he reaches the reverting-call switch. Next, the calling party dials the last (ringing) digit of his number and then that of the called party. These digits are stored in the reverting-call switch, and when the calling party hangs up, his station and the called party's station are alternately signaled. The first party which answers on that line trips the ringing, and conditions the equipment for subsequent release. If the called party does not answer, the calling party must momentarily lift the receiver and then hang up.

Reverting Call by Prefix to Directory Number

In certain exchange areas which utilize up to five digits for party selection, reverting calls are occasionally made by dialing a prefix to the directory number. Here too, as in the case of reverting call by special number, the subscriber must recognize the fact that the party he desires is on his own party line. The prefix number dialed merely provides access to special reverting-call equipment; subsequently, when the called party's regular directory number is dialed, the line-selecting digits are absorbed automatically, and only the ringing digits,

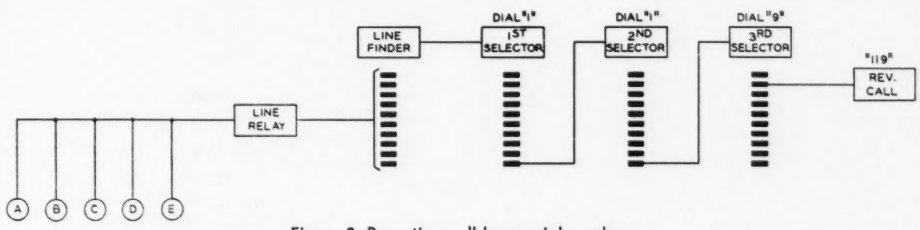


Figure 2. Reverting call by special number.

which contain information about ringing frequency, the side of the line to be rung, and code (if required), are utilized. The calling party is then required to hang up, and at that time the called party is signaled automatically. Since the reverting-call equipment has received only the called party's ringing information, the calling party is not signaled at this time. He will, however, hear the *called* party's signal if (1) bridged code ringing is used, or (2) divided code ringing is used and his ringer is connected to the same side of the line as the called party's. (If harmonic ringers are used in code ringing, he will, of course, not hear the ringing signal unless his ringer is of the same frequency as that at the called station). Since the calling party may not know whether or not the called party has answered, he is instructed to wait a reasonable length of time before answering. On the other hand, the called party may answer immediately, and to indicate that he should hold the connection until the calling party re-enters, a special reverting-call tone ("tick-tock" tone) is placed on the line for a short period of time. If the called party fails to answer, the calling party will trip the ringing when he re-enters the connection, and will release the switch train on subsequent release. In the event that no one answers, the equipment is usually designed to "time-out" and release after a reasonable length of time.

Reverting Call by Directory Number

On certain automatic switchboards, especially the small ones, reverting calls may be made by dialing the called party as is normally done, and then hanging up when busy tone is returned Operation is thereafter as described above.

This trunking situation is illustrated in Figure 3. The connector switch is of a special type so that the connection remains established after the calling party hangs up initially. This special switch contains more equipment, and is consequently more expensive than a standard connector switch. Since the equipment has no way of telling whether a reverting call is to be set up at the time the connector switch is seized, all of the connector switches must be of this special variety. This usually proves most economic in a small exchange area having a few connector switches, where using special reverting-call switches would be more expensive than the increased cost of special connector equipment

Usually with this type of equipment the switch train is released upon answer, and transmission battery is supplied from the line relay equipment common to that party line. Special lock-out equip-

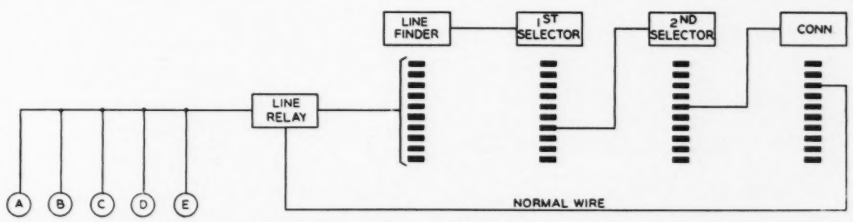


Figure 3. Reverting call by directory number.

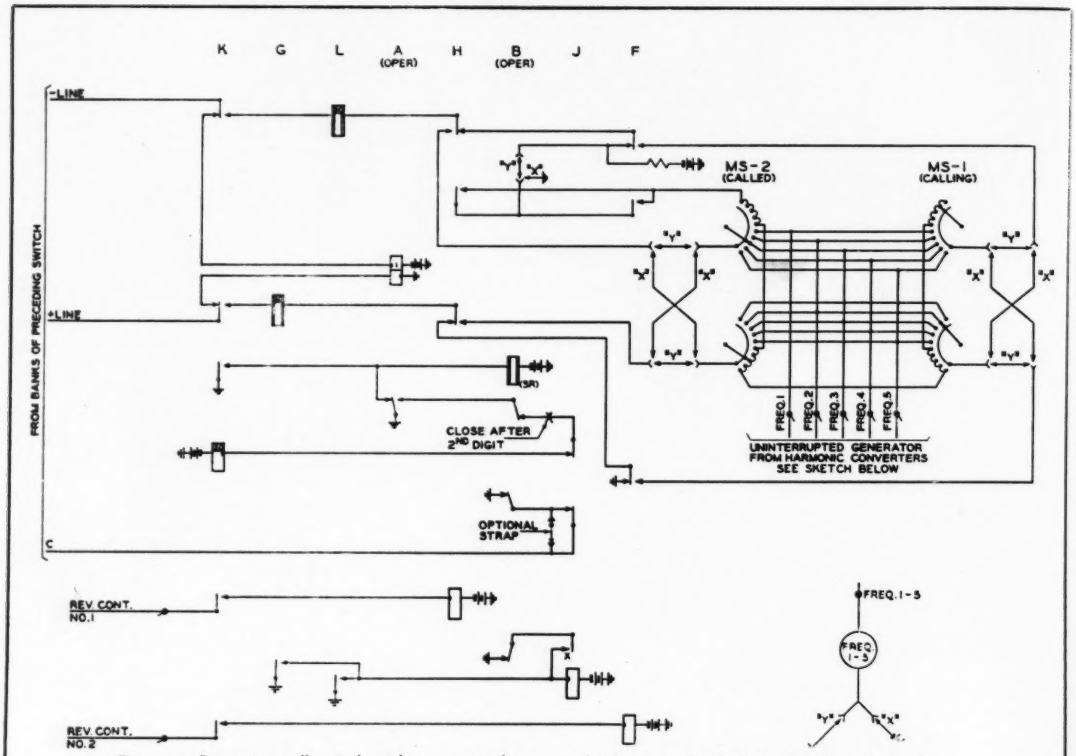


Figure 4. Reverting-call switch with ten party harmonic bridged or divided ringing. Two digits have been dialed into the minor switches, alternately stepping switches MS-1 and MS-2.

ment is required to prevent re-seizure of additional trunk selective equipment during conversation.

Reverting calls may also be made by directory number in exchanges having a "terminal-per-station" arrangement. In this case, however, each subscriber on a particular party line appears in a different connector group from the others, and hence his line-selecting (switch positioning) digits are different. In this system it is not possible for the calling party to identify the called party as being on the same party line; therefore, the telephone company will provide a list of numbers of the other subscribers on a party line. Since each connector group signals with a definite type of ringing, distinct from others serving the same party line, the line-selecting digits have automatically selected the type of ringing required.

In Table I is shown a summary of the different types of reverting-call systems.

Circuit Description

Figure 4 shows a reverting-call switch used in a ten-party harmonic bridged or divided ringing system. As shown, two digits have been dialed into the reverting-call switch, alternately stepping minor switches MS-1 and MS-2. The first digit corresponds to the ringing digit of the calling party; the second digit corresponds to the ringing digit of the called party. In Figure 4 the calling party's ringing digit was taken as 2, while the called party's ringing digit was assumed to be 8. Minor switches MS-1 and MS-2 are shown positioned accordingly, and relays A and B are shown in their operative positions. At this point the calling party hangs up. Ringing frequency No. 3 is sent out over the —line to signal the called party on the —line (divided ringing). If bridged ringers are used the ringing current would return over the +line to ground. The calling party is signaled with fre-

quency No. 2 on the +line. If either the called or calling party answers during ringing, a D.C. loop is closed between —line and +line to trip the ringing. The calling party re-enters the connection when his ringing stops.

With the above method of operation the reverting-call switch supplies talking current for both parties and is held during the entire conversation. If talking current is to be supplied from the line and cut-off relays of the party line, holding ground is removed from the C lead to the preceding switch train when the called party answers. This releases the entire switch train, including the reverting-call switch. Optional facilities are shown for a battery-connected generator.

Figure 5 shows a reverting-call switch using five-frequency bridged ringing with one and two rings. Here, too, the two minor switches have been positioned in accordance with the ringing digits of the calling and called parties. When the calling party restores his handset, the ringing cycle is initiated. Since a type of coded ringing (one or two rings) is employed it is imperative that the ringing cycle be synchronized to prevent mutilated signaling. A pick-up lead indicates the beginning of a cycle and causes the battery-connected generator to be connected to the —line. Synchronized ground pulses via the "reverse" lead bring about the change-over from signaling the called party to the calling party, while the relative positions of MS-1 and MS-2 determine whether the signaling is to be one-ring or two-ring. In this particular circuit, digits 1 to 5 are arranged for one-ring and digits 6 to 0 for two-ring. The calling party re-enters the connection when his ringing stops.

In the circuit of Figure 6, a reverting-call switch is shown for a ten party, coded, divided ringing system. As in the other circuits, the minor switches are positioned in accordance with the ringing digits of the called and calling parties. Since this switch employs coded ringing, a pick-up lead is incorporated in the circuit to insure that the ringing code starts at the beginning of each cycle to prevent false answer by another sub-

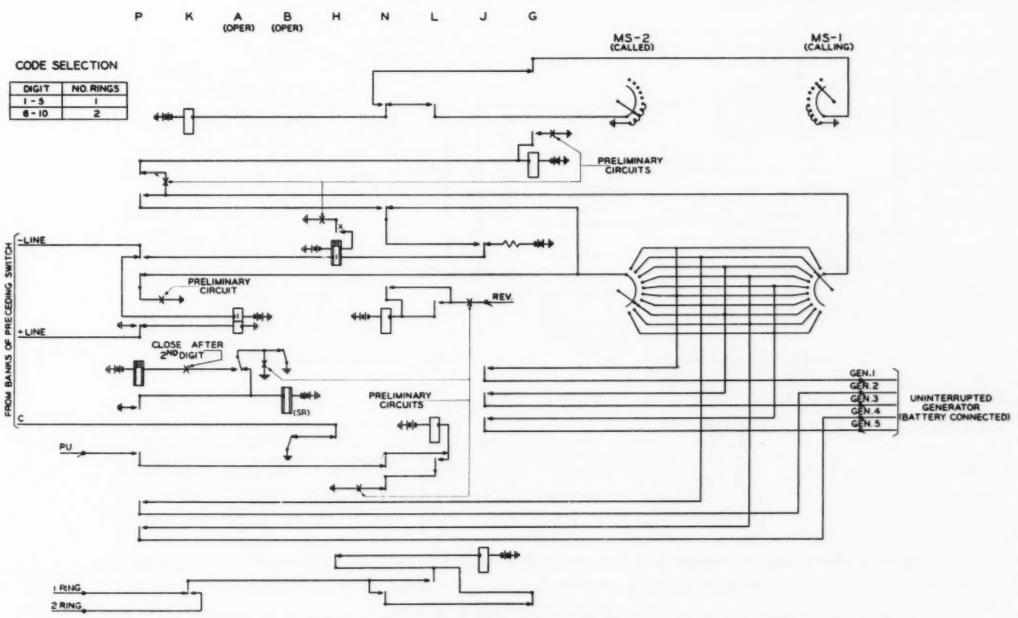
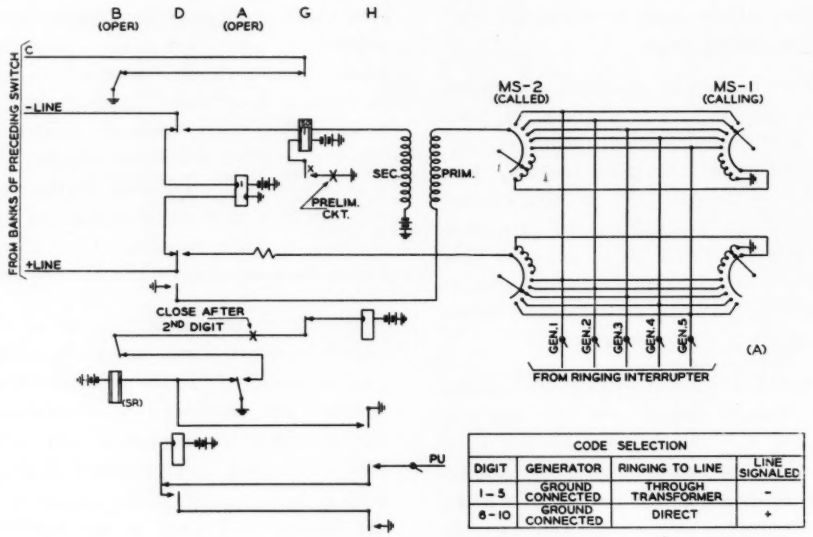
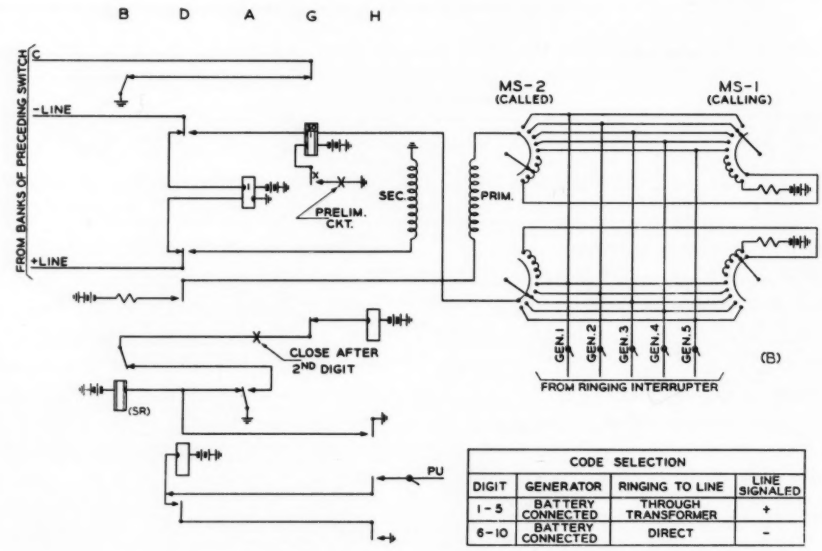


Figure 5. Reverting-call switch with one and two ring, five frequency bridged ringing. Two digits have been dialed into the minor switches, alternately stepping switches MS-1 and MS-2.



CODE SELECTION			
DIGIT	GENERATOR	RINGING TO LINE	LINE SIGNALED
1-5	GROUND CONNECTED	THROUGH TRANSFORMER	-
6-10	GROUND CONNECTED	DIRECT	+



CODE SELECTION			
DIGIT	GENERATOR	RINGING TO LINE	LINE SIGNALED
1-5	BATTERY CONNECTED	THROUGH TRANSFORMER	+
6-10	BATTERY CONNECTED	DIRECT	-

Figure 6. Reverting-call switch with ten party, five code ringing. Two digits have been dialed into the minor switches, alternately stepping switches MS-1 and MS-2.

(A) ground connected generator

(B) battery connected generator

scriber. This particular circuit arrangement signals both the calling and called parties if they have their ringers connected to opposite sides of the lines. This is desired here to give the calling party an indication when the called party answers. If both the calling and called parties have their ringers connected from the same side of the line to ground, only the called party's code will be sent out. Of course, since straight-line ringers are employed, the calling party (and all other parties on that line) will hear the signaling, and he will reenter after the called party answers.

Compared to a ringing cycle in a harmonic ringing system the code ringing cycle used here is long. Because of this it is not desirable to provide for alternate signaling of the calling and called parties. Instead, both parties are signaled simultaneously (when their ringers are on opposite sides of the line), and transformers are used to isolate both ringing codes. The ringers are either signaled directly or through a transformer, as illustrated in the tables in Figure 6.

Figure 7 shows a reverting-call switch on a four party selective or eight party semi-selective superimposed ringing arrangement. In a fully selective ringing system, during a regular nonrevertive call, only the called party is signaled during ringing, while in a semi-selective system an additional party hears the called party's signal but does not answer since he recognizes that it is not his own ringing code. It can be seen that, as in previous circuits, the called and calling parties' ringing conditions have been chosen, and the ringing cycle will start when the called party restores his handset to the cradle. Again the one-ring or two-ring condition requires a pick-up lead, but the point of interest here is the manner in which the ringing current is imposed upon the line with either a positive or negative D.C. bias voltage to activate one type of biased ringer on either side

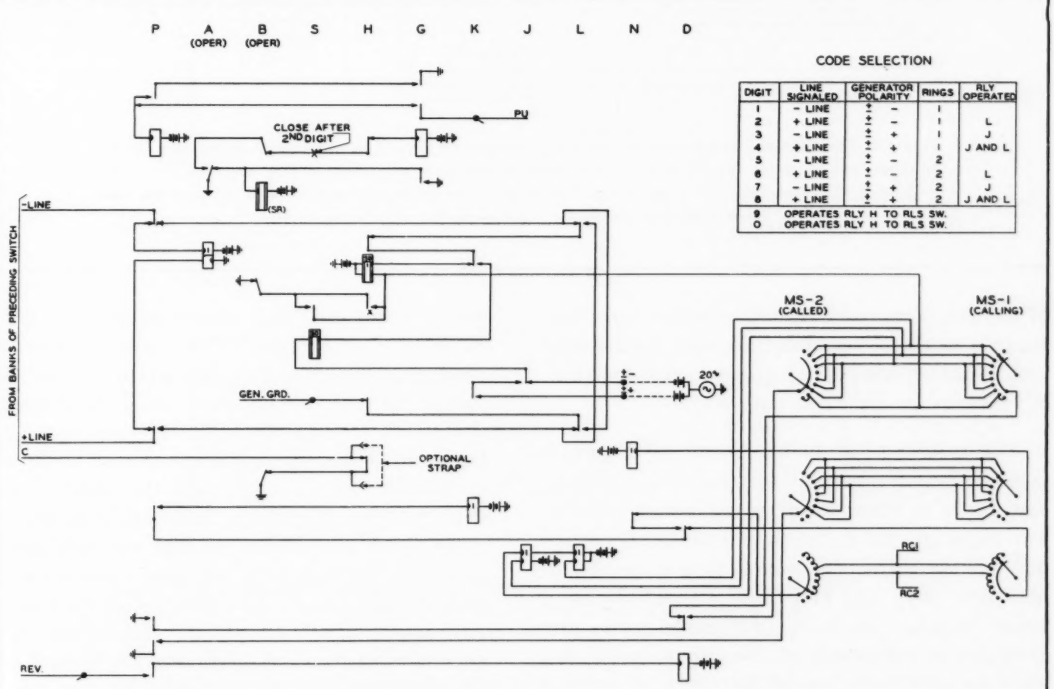

P
A (OPER)
B (OPER)
S
H
G
K
J
L
N
D
CODE SELECTION
DIGIT | LINE SIGNALED | GENERATOR POLARITY | RINGS | RLY OPERATED
1 | - LINE | ± – | 1 |
2 | + LINE | ± – | 1 | L
3 | - LINE | ± + | 1 | J
4 | + LINE | ± + | 1 | J AND L
5 | - LINE | ± – | 2 |
6 | + LINE | ± – | 2 | L
7 | - LINE | ± + | 2 | J
8 | + LINE | ± + | 2 | J AND L
9 OPERATES RLY H TO RLS SW.
0 OPERATES RLY H TO RLS SW.
PU
CLOSE AFTER 2ND DIGIT
(SR)
-LINE
FROM BANKS OF PRECEDING SWITCH
+LINE
C
GEN. GRD.
20~
OPTIONAL STRAP
MS-2 (CALLED)
MS-1 (CALLING)
RC1
RC2
REV.

Figure 7. Reverting-call switch with four party selective or eight party semi-selective superimposed ringing. Two digits have been dialed into the minor switches, alternately stepping switches MS-1 and MS-2.

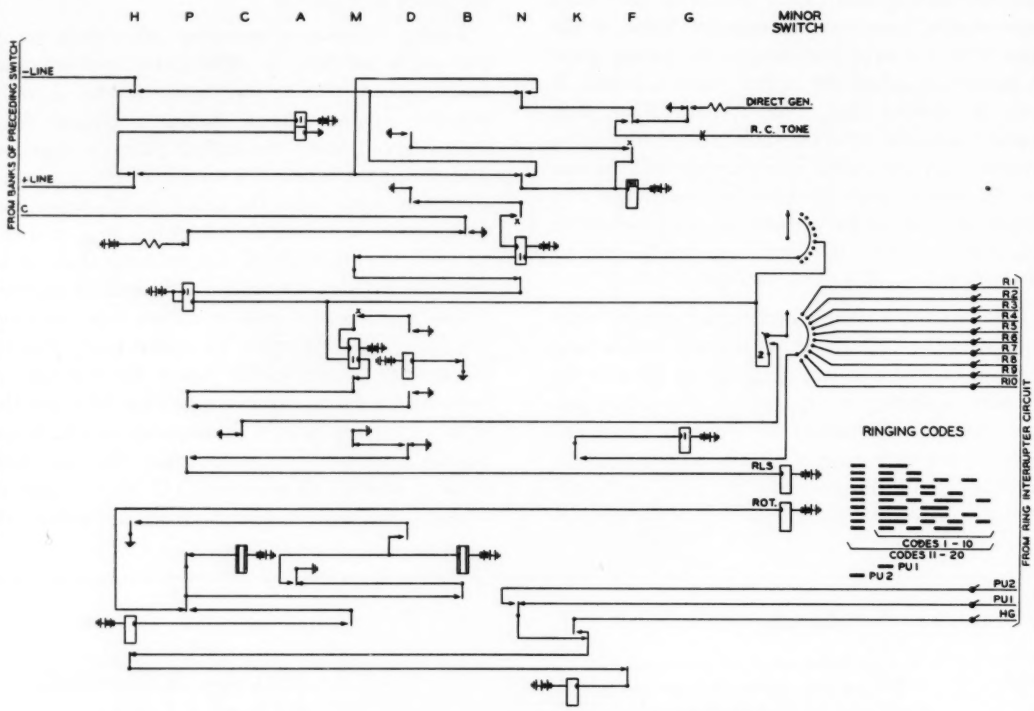


Figure 8. Reverting-call switch with twenty party bridged ringing. If the first digit dialed is 6 (or as strapped on the minor switch) relay N will operate and lock, preparing ringing over the "+" line and using PU2 with codes 11 - 20. If the first digit is not strapped, relay N will not operate, and ringing will start on the "—" line using PU1 with codes 1 - 10.

of the line. This system is fully selective (only one party is aware of signaling) for four parties only and, as shown with one-ring or two-ring facilities, is semi-selective for eight parties.

The reverting-call switch circuit of Figure 8 is used in a twenty-party bridged, coded ringing system. As in other reverting-call switch circuits, two digits are dialed into this circuit but here they are used to choose one out of twenty parties on the party line. The first digit is registered on a minor switch, and in the interdigital pause the strapping on the bank of this minor switch determines whether the called party is to be signaled with codes 1 to 10 or with codes 11 to 20. At this time the minor switch restores and is made ready to receive the second digit dialed into the reverting-call switch. This digit picks one code out of the group of ten previously chosen by the first digit. As in the case of other circuits employing coded ringing, a pick-up lead is incorporated in the circuit to prevent the signaling from beginning in the middle of the code. The codes are shown on Figure 8. It can be seen that codes 11 to 20 are identical to codes 1 to 10, with the addition of a short prefixed ring. Only ten ringing-interrupter cycles are required since the first and last groups of ten are the same, with one pulse masked out on each of codes 1 to 10. This circuit does not register any information for signaling the calling party since it is not required; all ringers are bridged and all subscribers hear the ringing codes. This circuit is reached from preceding equipment and utilizes two digits required to identify any of the called parties. Note that only one minor switch is required to accomplish the above task.

Figures 9(B) and 9(C) illustrate a reverting call made by a connector switch. The special revertive connector is shown being released from an ordinary busy condition in Figure 9(B) where the "C" wiper (control wiper) is grounded from another connector. Upon release of the circuit by the calling party, the connector and the entire preceding switch train release. Figure 9(C) shows that the busying ground on the "CN" (control normal) lead is connected to the "C" wiper. Therefore, when the calling party hangs up on this revertive call, the connector alone is held locked up and the remainder of the switch train releases. The connector is then conditioned for revertive ringing.

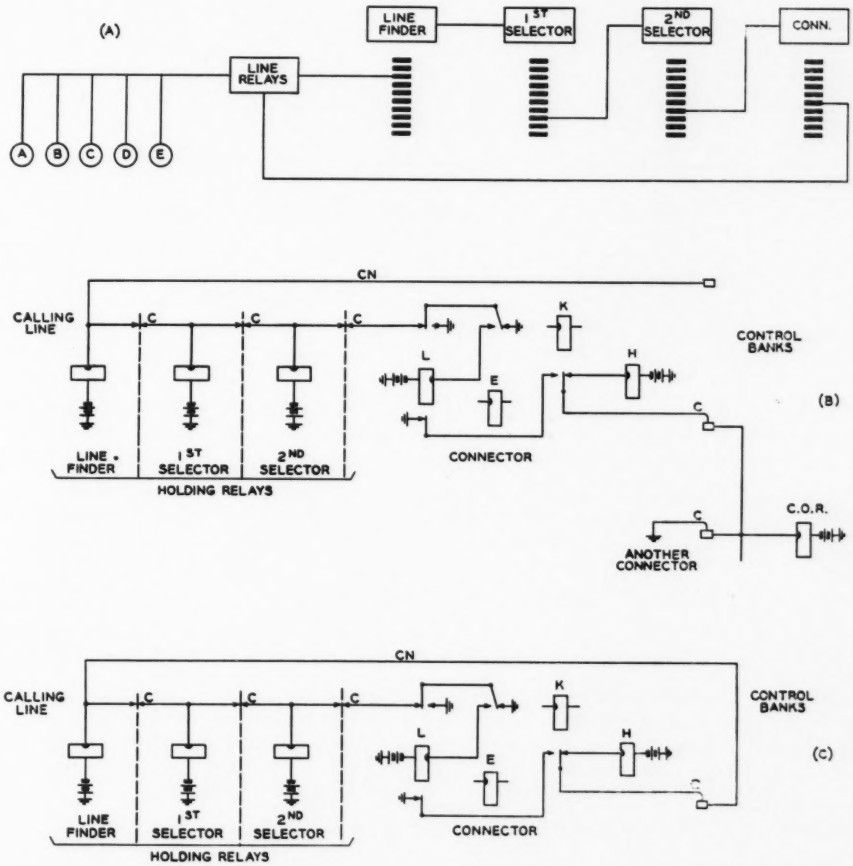


Figure 9. Reverting-call by Connector Switch. 9(A) Reverting-call trunking situation. 9(B) Ordinary busy condition. 9(C) Revertive-call condition. Figures 9(B) and 9(C) show relay E operated, as when C-wiper reaches a busy line. In both cases, relay H operates and locks. Upon release by calling party, relay K operates and relay E releases. In Figure 9(B) the C wire and CN have no ground, hence all relays release. In Figure 9(C), CN is grounded by the C-wiper through contacts of relays K and L; hence relay L operates and locks, removing ground from both ends of the C wire. All holding relays release. Only the connector remains operated with relay L conditioning the circuit for revertive ringing.

Miscellaneous Considerations

Transmission

Two types of battery feed arrangements are used on reverting calls. If the reverting-call switch is held during conversation it will provide battery feed. However, if the reverting-call switch releases during conversation, battery feed is supplied from the line relay. In the latter case fewer reverting-call switches are required but, on the other hand, all party lines must be arranged in such a fashion as to prevent re-seizure of additional trunk selecting equipment. This prevents dial tone from being heard during this type of reverting call; also, the line is held busy from the line and cut-off relay equipment. This feature is known as "line-lockout", and if all of the lines are so arranged the condition is referred to as "100% line-lockout".

Testing Facilities

It is possible for a testman to service a subset at the subscriber's station without assistance from anyone at the central office by dialing a reverting call. Here, the subscriber's own ringing digit would be dialed twice, and upon restoring, that station would be signaled either once or twice for each ringing cycle, depending upon the type of reverting-call equipment used. If the reverting call is made by dialing the directory number alone, the subscriber's own station would ring.

TABLE I — TYPES OF REVERTING-CALL SYSTEMS

	Reverting call by special number	Reverting call by prefix to directory number	Reverting call by directory number.
Numbers to be dialed.	Special number to seize reverting-call switch and then 2 digits into reverting-call switch.	Directory number prefixed by a special number.	Directory number.
Special switches required for reverting calls.	Special reverting-call switches accessed from certain selector bank levels.	Relatively few special revertive connectors. These are chosen by first digit or digits.	All special revertive connectors for party line service.
Action occurring after calling party hangs up after dialing.	Reverting-call switch locks up and starts ringing calling and called subscribers. Ringing is determined by 2 digits dialed previously into minor switches.		Special connector locks to busying ground from itself over CN wires and drops preceding switch train. It then sets itself for ringing subscribers.
Action occurring after calling or called party answers.	Revertive connector, or reverting-call switch either conditions itself to supply transmission battery to the subscribers, or else releases itself and the switch train (if not already released), the transmission battery being supplied by the line relays. This latter method is used only when party lines have 100% line lockout so that no additional equipment will be tied up and dial tone will not be heard during conversation.		
Type of ringing.	The ringing may be coded, harmonic, or superimposed; fully or semi-selective. In some systems, both subscribers' stations are signaled while others signal only the called party. With coded ringing it is desirable to signal the called party only when both parties have ringers on the same side of the line. With other systems the calling party receives no signal whatsoever and is instructed to wait a reasonable length of time before answering. In this case the called party usually receives a special reverting-call tone on answering.		

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